

Atmospheric Pressure and Wind

Chapter 5

The Nature of Atmospheric Pressure

- **Atmospheric Pressure is the force exerted by the gas molecules on some area of the Earth's surface or on any body.**
 - **This pressure is exerted on every solid or liquid surface it touches**
 - **It is omni-directional, exerted equally in all directions.**
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Factors Influencing Atmospheric Pressure

- **Density and Pressure**
 - **Density is the mass of matter in a unit volume**
 - The density of a gas is proportional to the pressure on it and the pressure the gas exerts is proportional its density. The denser the gas, the greater the pressure it exerts.
 - **Atmosphere is held to the Earth by gravity.**
So as the air moves away from the Earth, there is less gravity and less density, thus less pressure.
 - **Higher altitude, less density, less pressure**
 - **Lower altitude, higher density, higher pressure**
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Factors Influencing Atmospheric Pressure

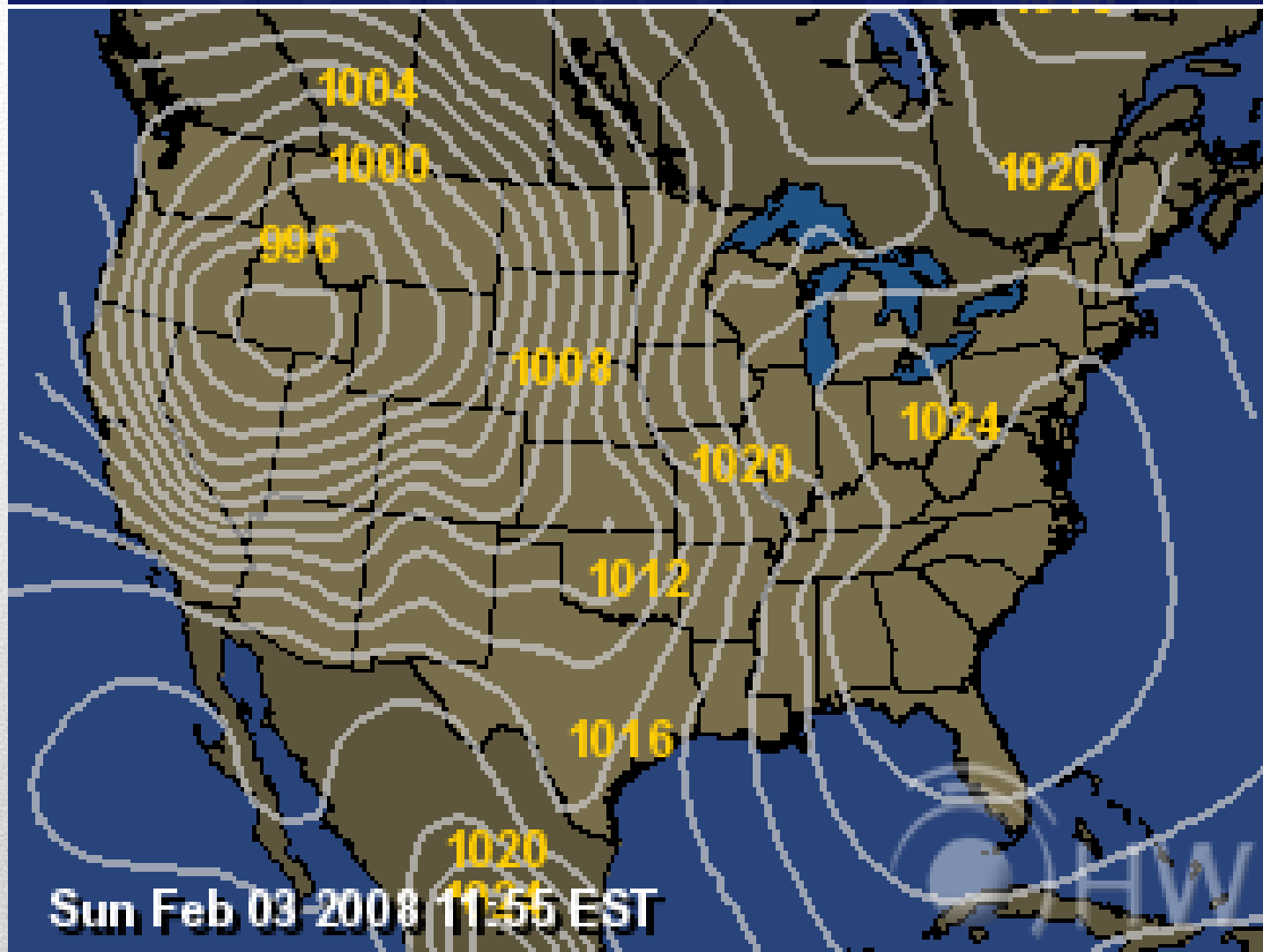
- **Temperature and Pressure**
 - If volume is held constant
 - An increase in temperature produces an increase in pressure,
 - A decrease in temperature produces a decrease in pressure.
 - Imagine a balloon, if it's hot, it will burst, if it's cold it deflates.
 - One factor to change this (important)
 - As air rises, the molecules will spread out, so pressure does decline as does the temperature.
 - As air is compressed or altitude is lowered the molecules are compressed and the pressure is increased and the temperature increases
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Dynamic Influences on Air Pressure

- Atmospheric pressure is affected by:
 - Differences in air density
 - Air temperature
 - Air movement
 - High and Low Pressures
 - Strongly descending air /with high pressure at the surface –
Dynamic high
 - Very cold surface conditions /with high pressure – **Thermal High**
 - Strongly rising air associated with low pressure at the surface –
Dynamic low
 - Very warm surface conditions /with low pressure – **Thermal low**
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Current Pressure

HAMweather.com

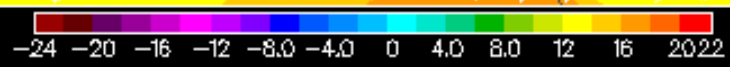
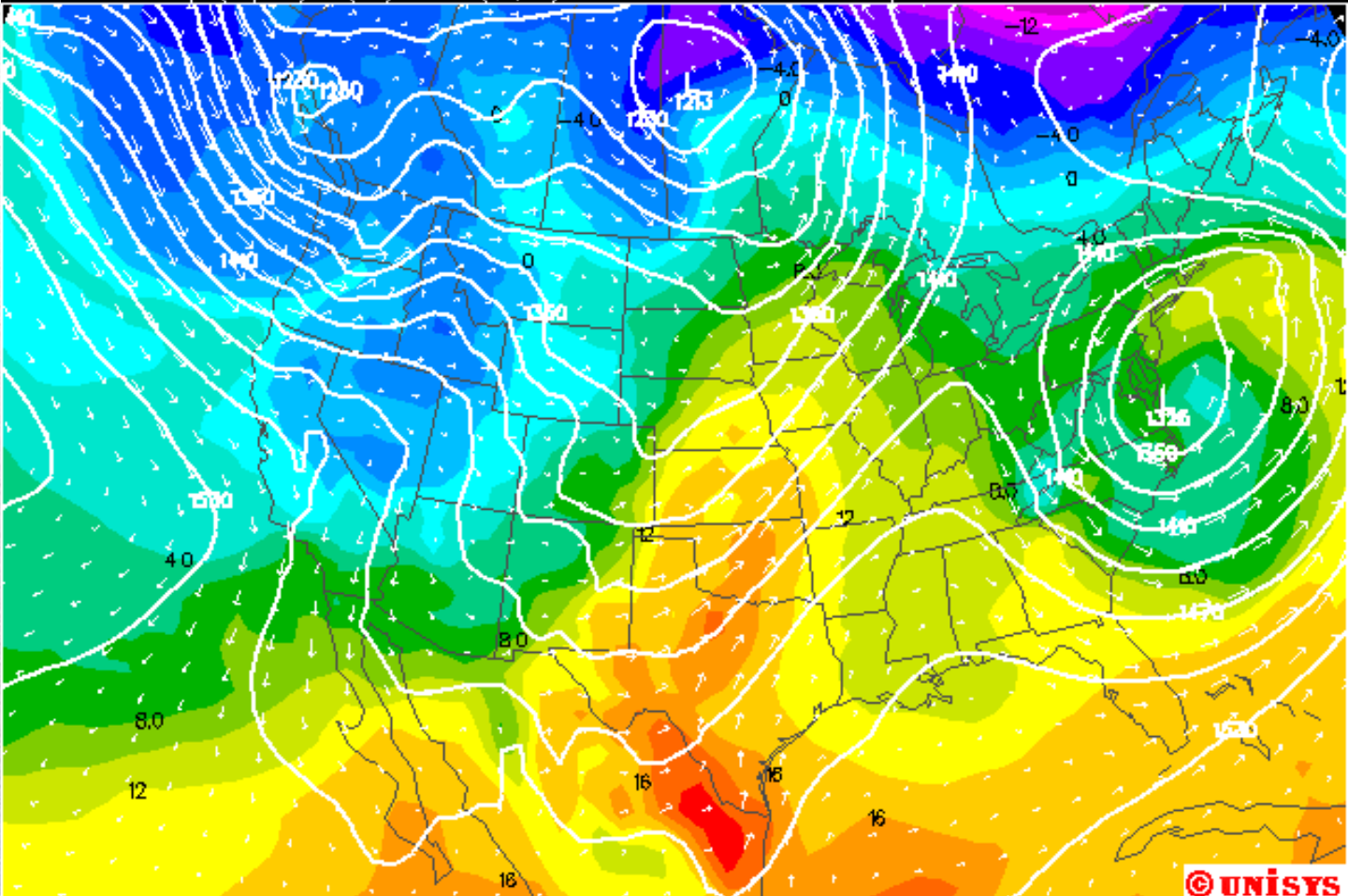


Mapping Pressures with Isobars

- Atmospheric pressure mapped with **isobars**
 - Measured with **Barometers**
 - Measurements
 - **Millibars**
 - **Highs and Lows**
 - **Ridges and Troughs**
 - **Pressure gradients**
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850 mb temp (C) hght (m) wind (m/s)

3 day GFS valid 12Z TUE 29 MAR 05



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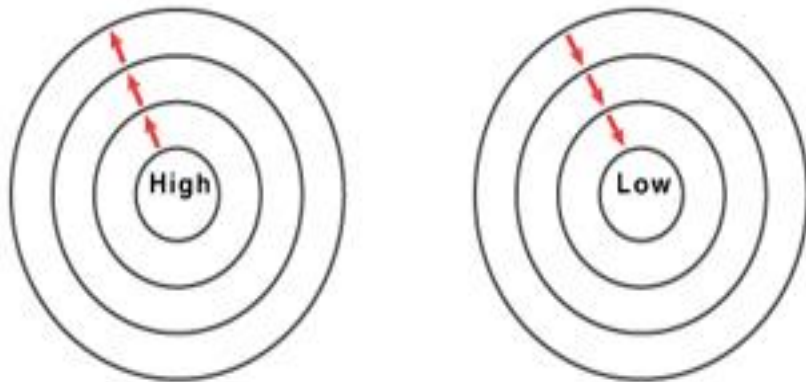
MAX VECTOR: 29.3 m/s →

The Nature of the Wind

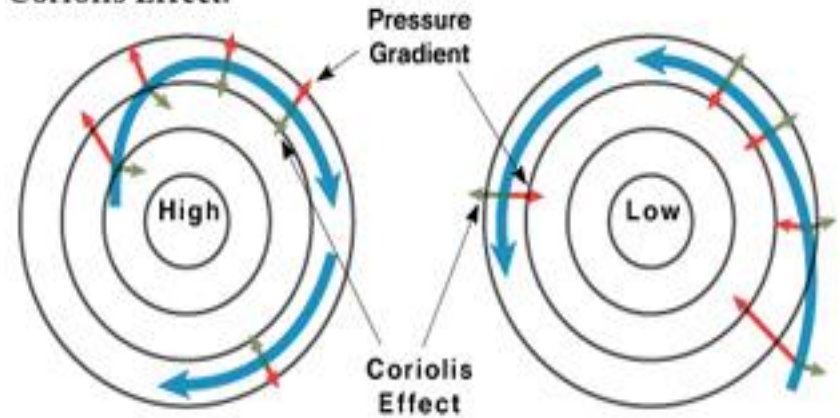
- **Direction of Movement**
 - **Pressure Gradient**
 - **Pressure-gradient force acts at right angles to the isobars in the direction of the lower pressure**
 - **The Coriolis Effect**
 - **The Coriolis Effect deflection acts at 90 degrees from the direction of movement, right in the north, left in the south.**
 - **Friction**
 - **In lowest portions of the troposphere friction slows the wind movement, thus influencing the Coriolis effect by reducing it.**
 - **Friction Layer extends only about 1000 meters above the ground.**



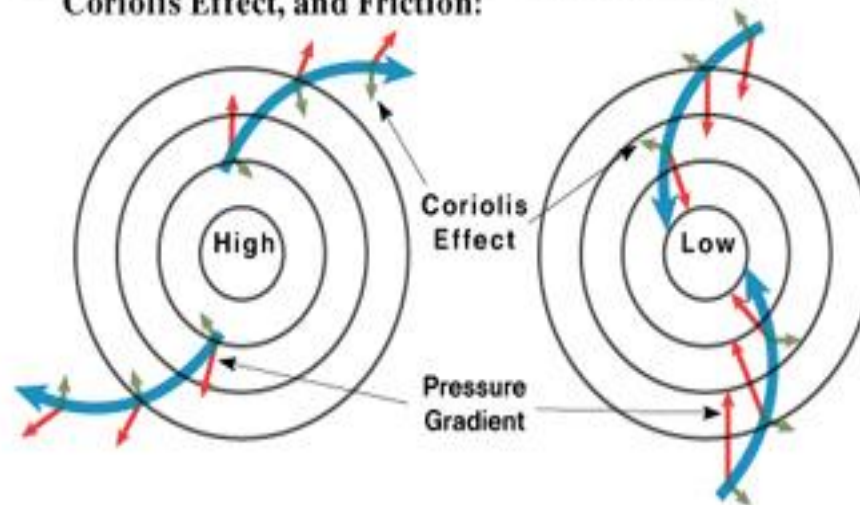
(a) Pressure Gradient Force only:



(b) Upper Atmosphere---Pressure Gradient Force and Coriolis Effect:



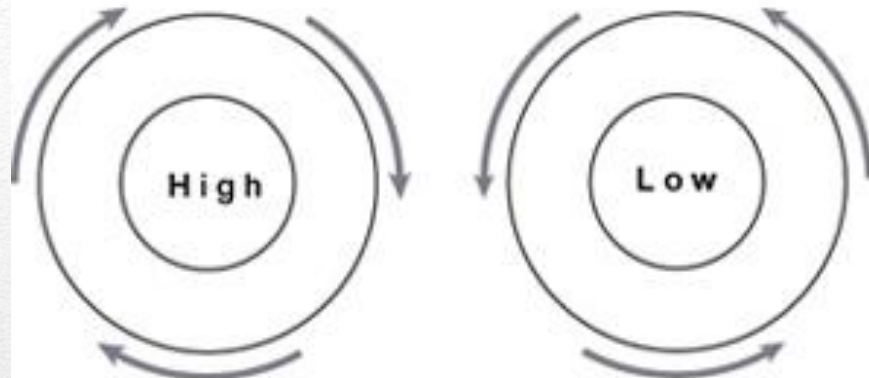
(c) Lower Atmosphere---Pressure Gradient Force, Coriolis Effect, and Friction:



Cyclones and Anticyclones

- **Distinct and predictable wind-flow patterns develop around all high and low pressures centers**
 - **Northern hemisphere**
 - **Low pressures – counter clockwise**
 - **High pressures – clockwise**
 - **Southern hemisphere**
 - **Low pressures – clockwise**
 - **High pressures – counter clockwise**
 - **Wind Speed**
 - **If the gradient is steep, the wind speed is fast**
 - **If the gradient is gentle the wind speed is slow**
-

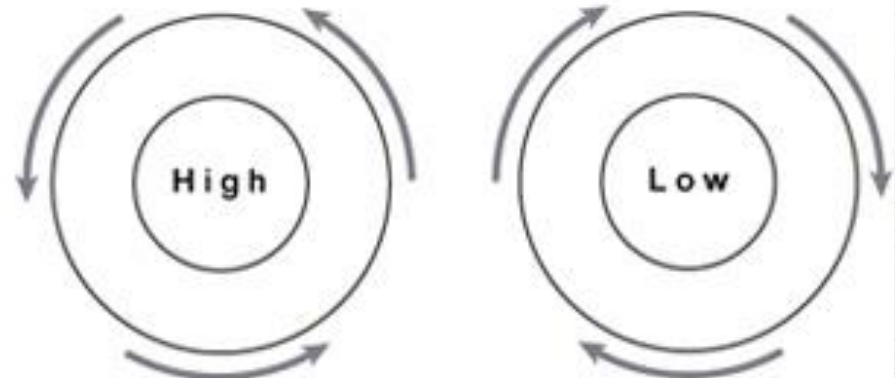
Northern Hemisphere upper-air pattern



Anticyclonic geostrophic
clockwise flow

Cyclonic geostrophic
counterclockwise flow

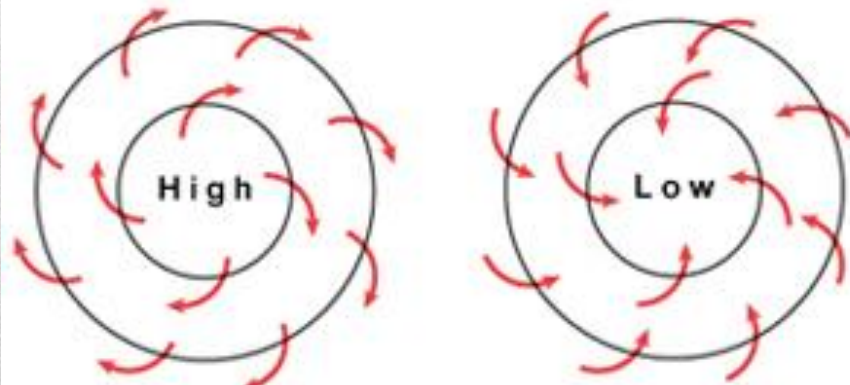
Southern Hemisphere upper-air pattern



Anticyclonic geostrophic
counterclockwise flow

Cyclonic geostrophic
clockwise flow

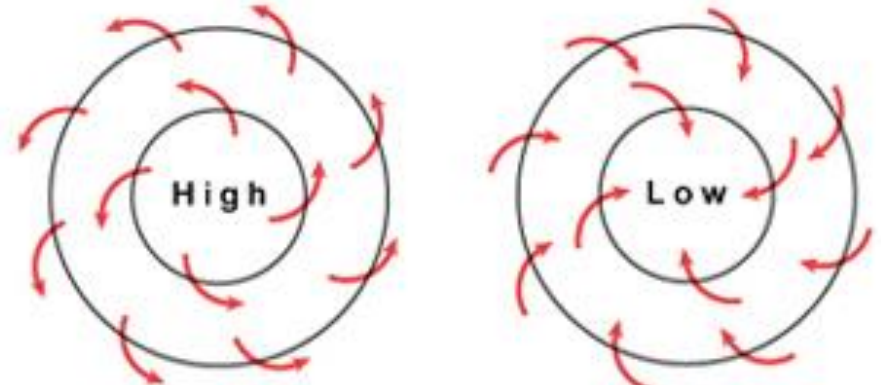
Northern Hemisphere friction-layer pattern



Anticyclonic divergent
clockwise flow

Cyclonic convergent
counterclockwise flow

Southern Hemisphere friction-layer pattern

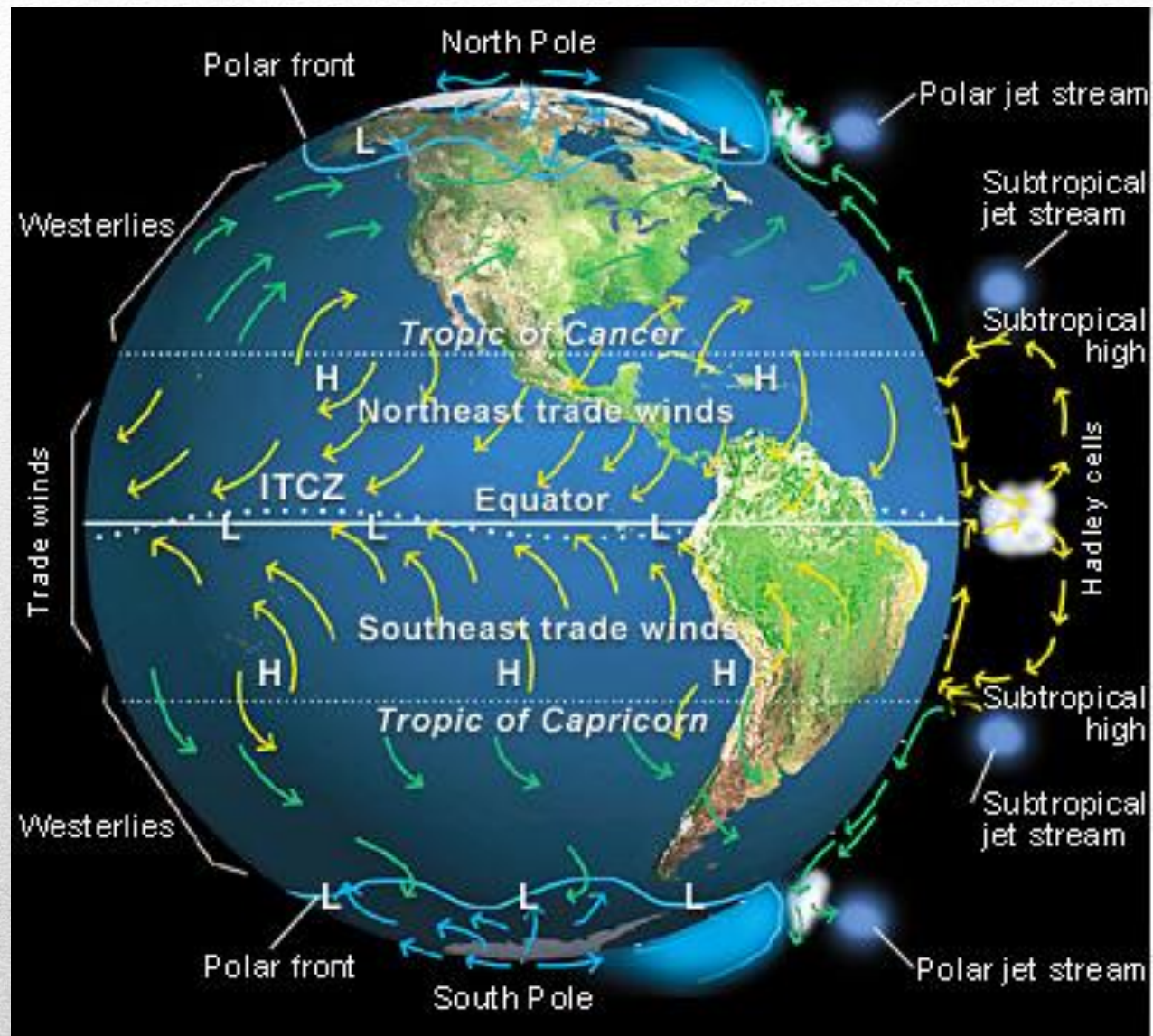


Anticyclonic divergent
counterclockwise flow

Cyclonic convergent
clockwise flow

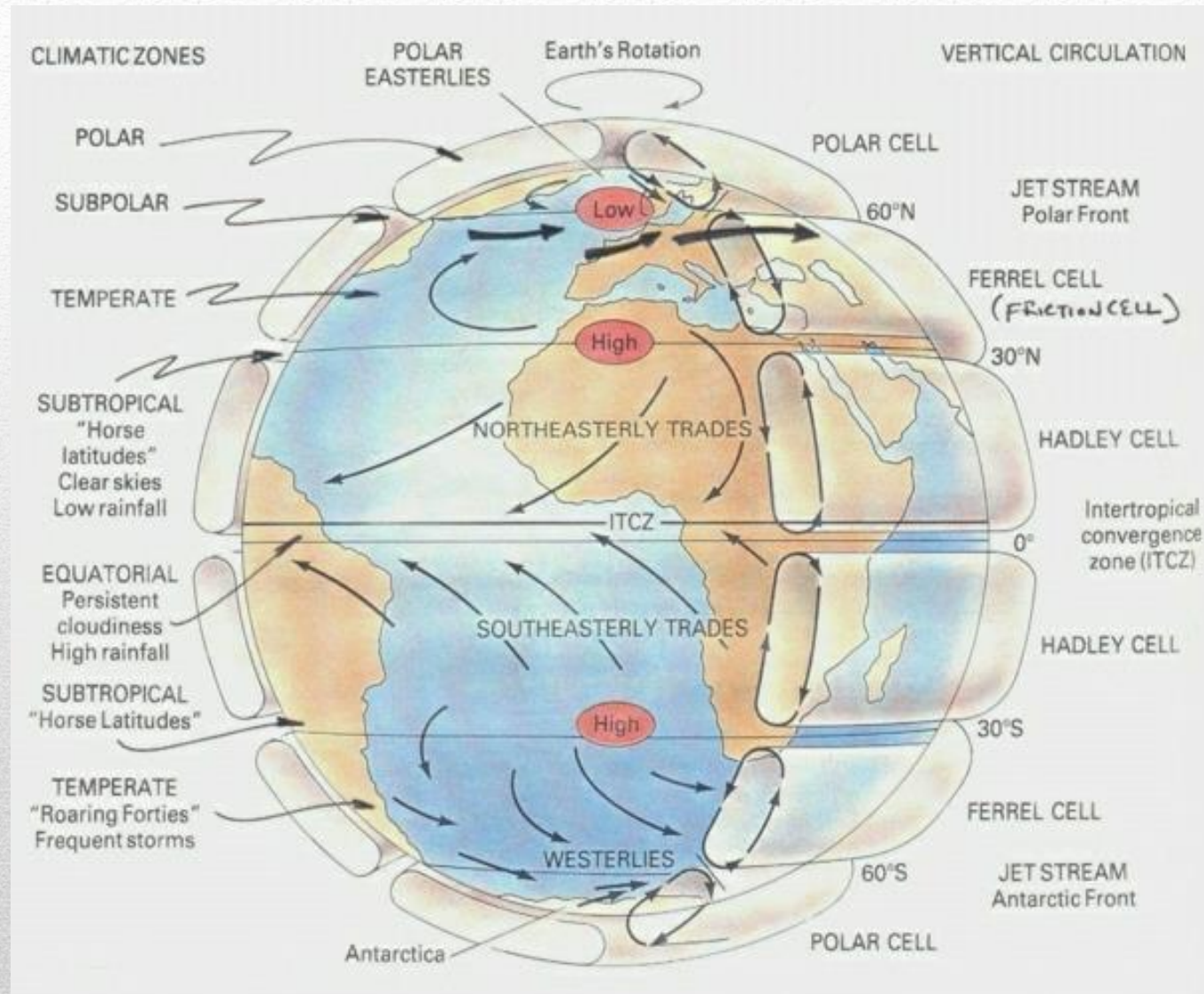
General Circulation of the Atmosphere

- There are seven atmospheric components ranging from the equator to the pole, both north and south
 - Polar High
 - Polar Easterlies
 - Polar Front (Subpolar Low)
 - Westerlies
 - Subtropical High
 - Trade Winds
 - Intertropical Convergence Zone (ITZ)
-



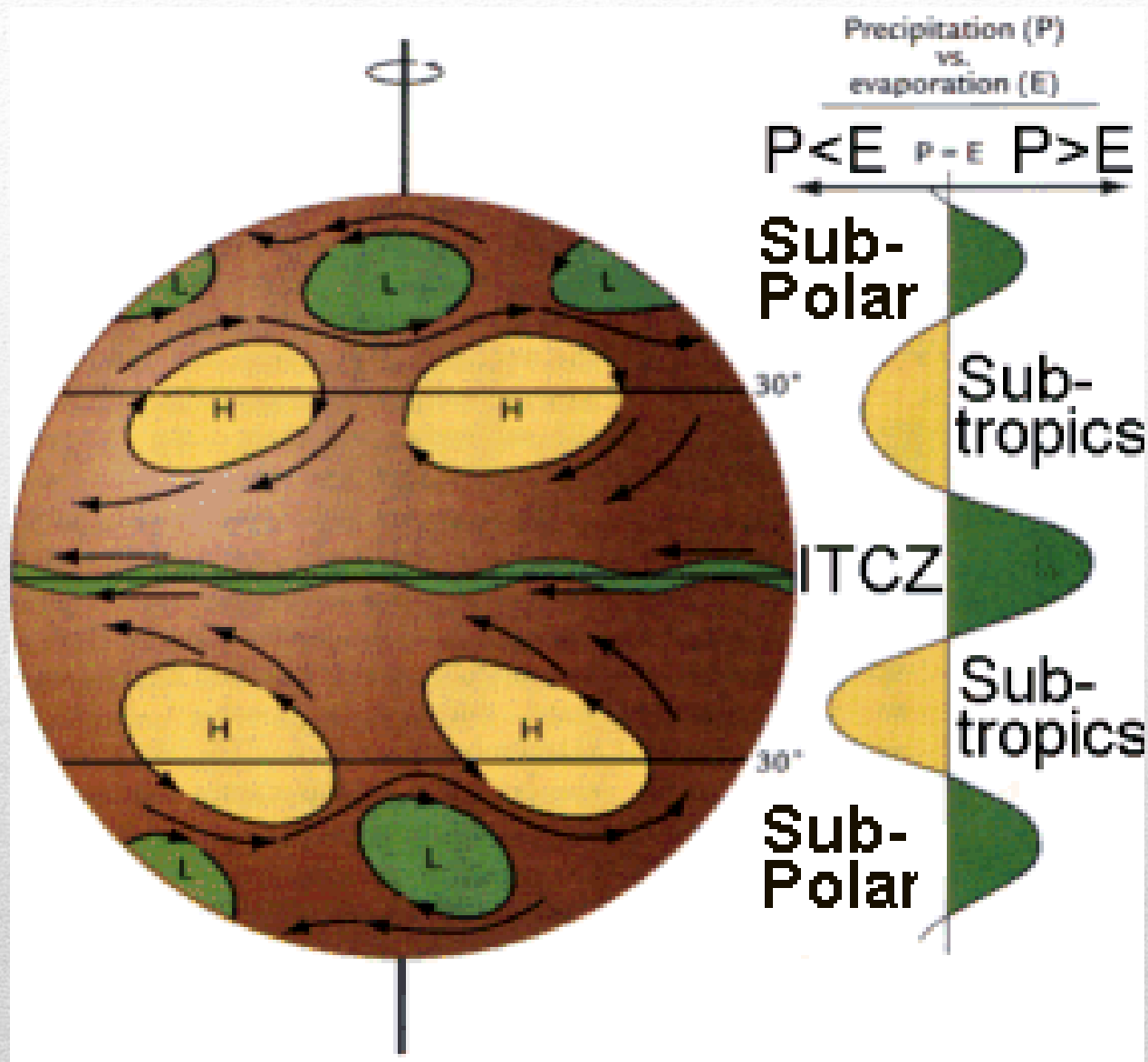
General Circulation of the Atmosphere

- **Earth's atmosphere is a dynamic medium**
 - The circulation of the atmosphere is the **principal mechanism for both longitudinal and latitudinal heat transfer and global patterns of insolation as a determinant of world climates**
 - **Cells of circulation only exist in the low latitudes, called Hadley cells.**
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Circulation of the Atmosphere

- **Subtropical Highs (STH) Horse Latitudes**
 - 30 degrees latitudes, large high pressure area over the oceans, clear, warm, calm weather
 - **Trade Winds**
 - Moving out from the equator toward sides of the STHs, and toward the west, used by sailors to quickly move sailing trading ships.
 - **Intertropical Convergence Zone (ITCZ)**
 - Where the Northeast and Southeast Trade Winds come together in the vicinity of the equator. Calm winds, doldrums, narrow cloud bands.
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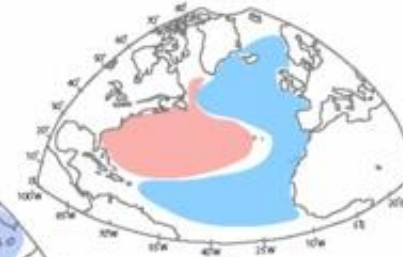
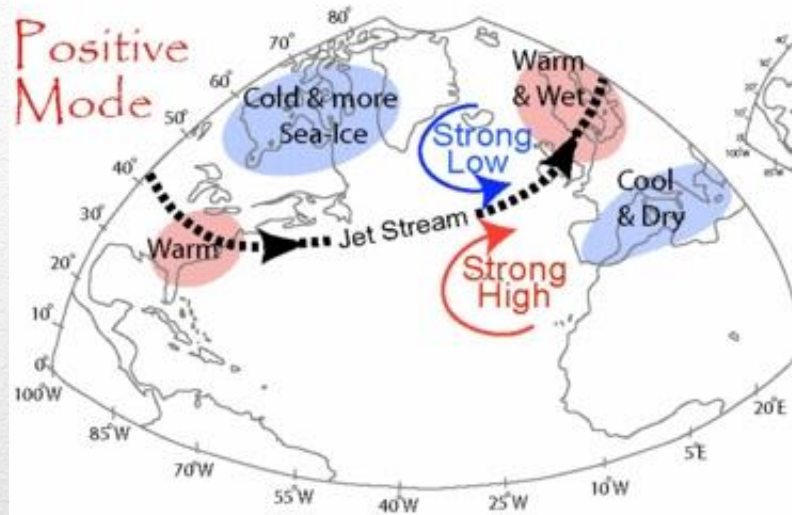
Circulation of the Atmosphere

- Westerlies (Mid latitudes Winds)
 - Flow west to east in the mid latitudes, 30 to 60 degrees, cover much of the earth
 - Surface Westerlies not strong, but in upper atmosphere, found in the Jet Streams
 - Polar Front Jet Stream,
 - Subtropical Jet Stream
 - Rossby Waves, waves in the jet streams towards the poles and the equator
 - Zonal and meridional flows



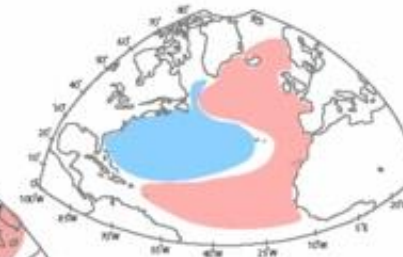
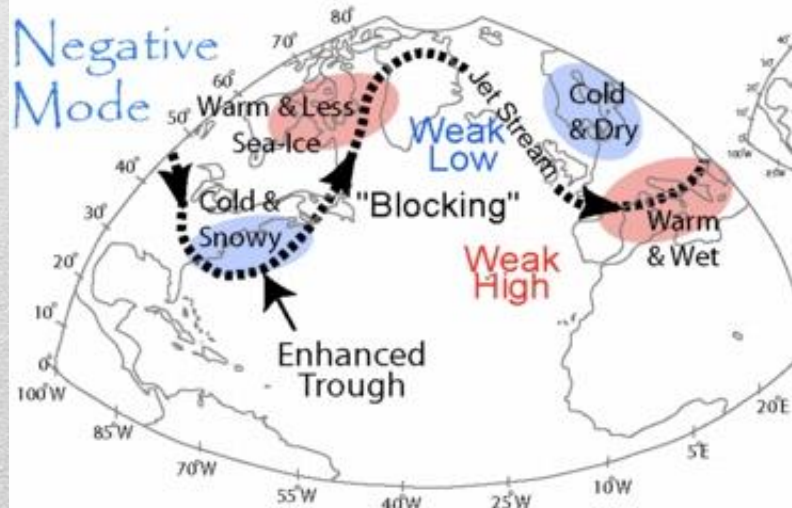
North Atlantic Oscillation

Positive
Mode



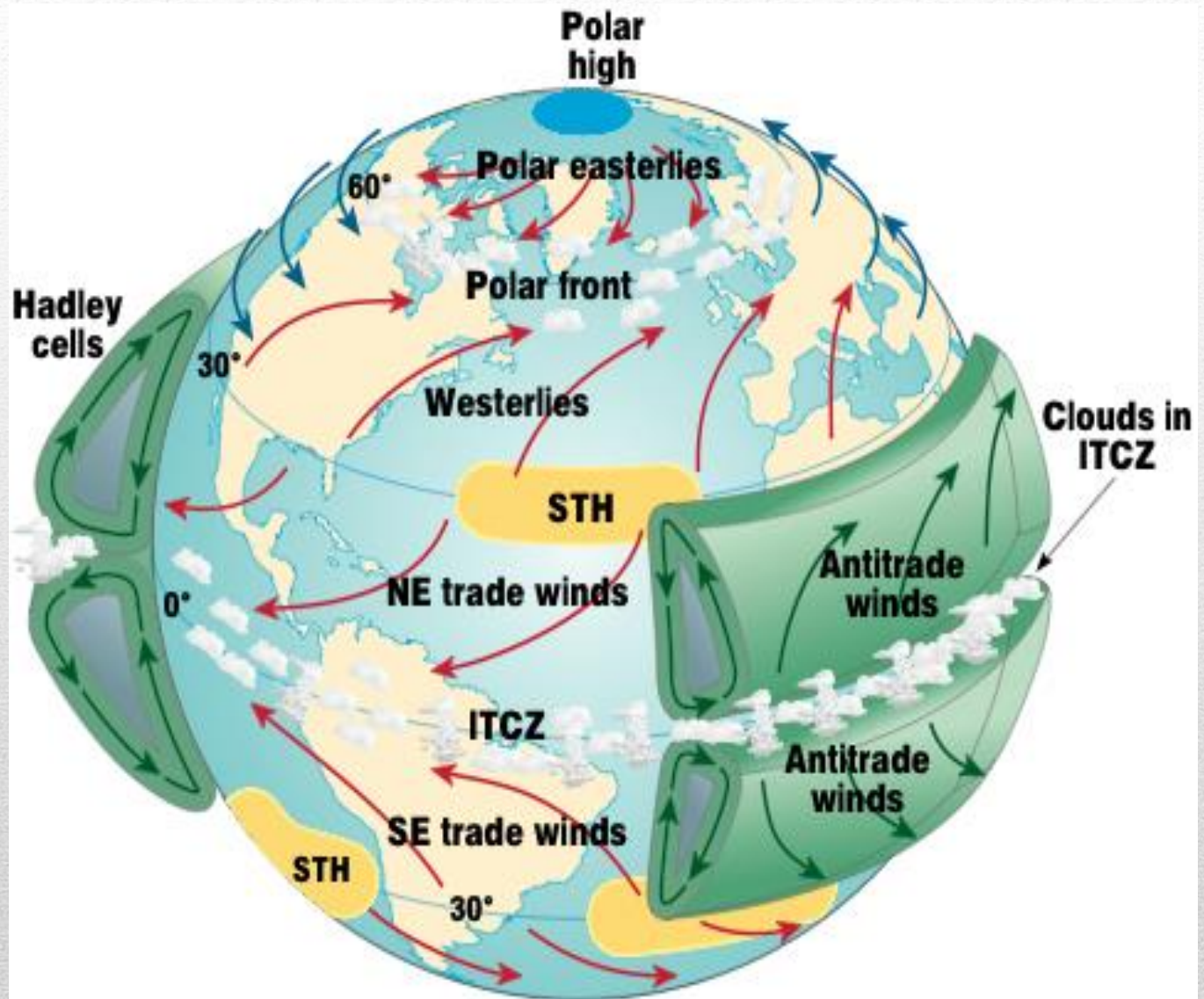
Associated
SST Patterns
(~12-14 yr period)

Negative
Mode



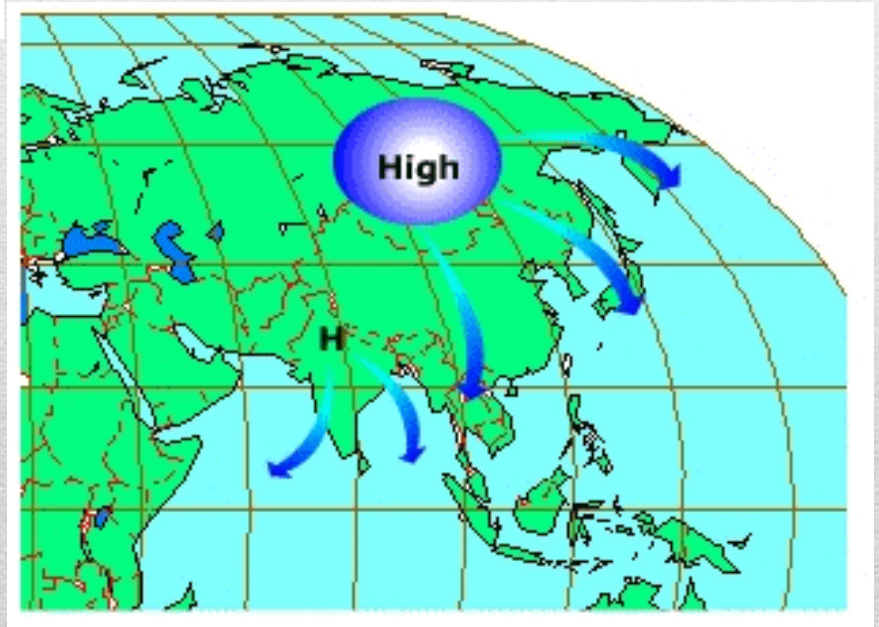
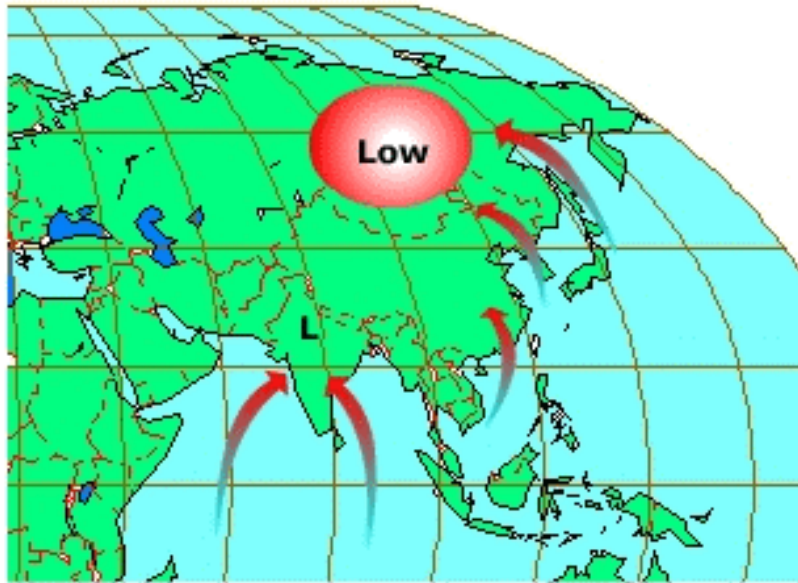
Circulation of the Atmosphere

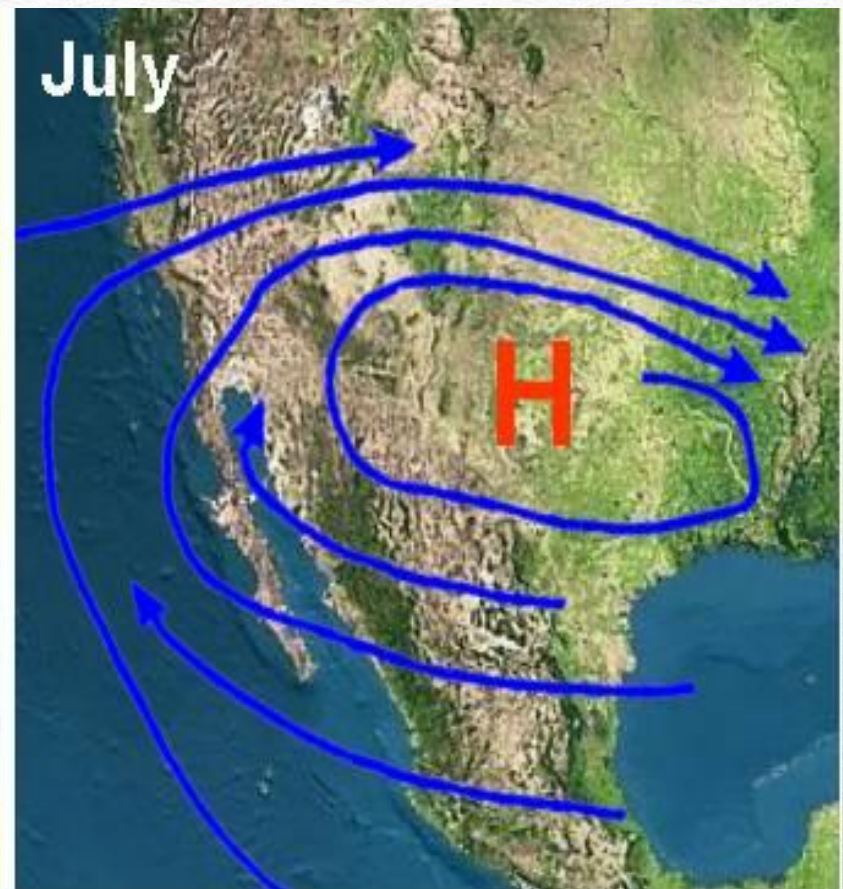
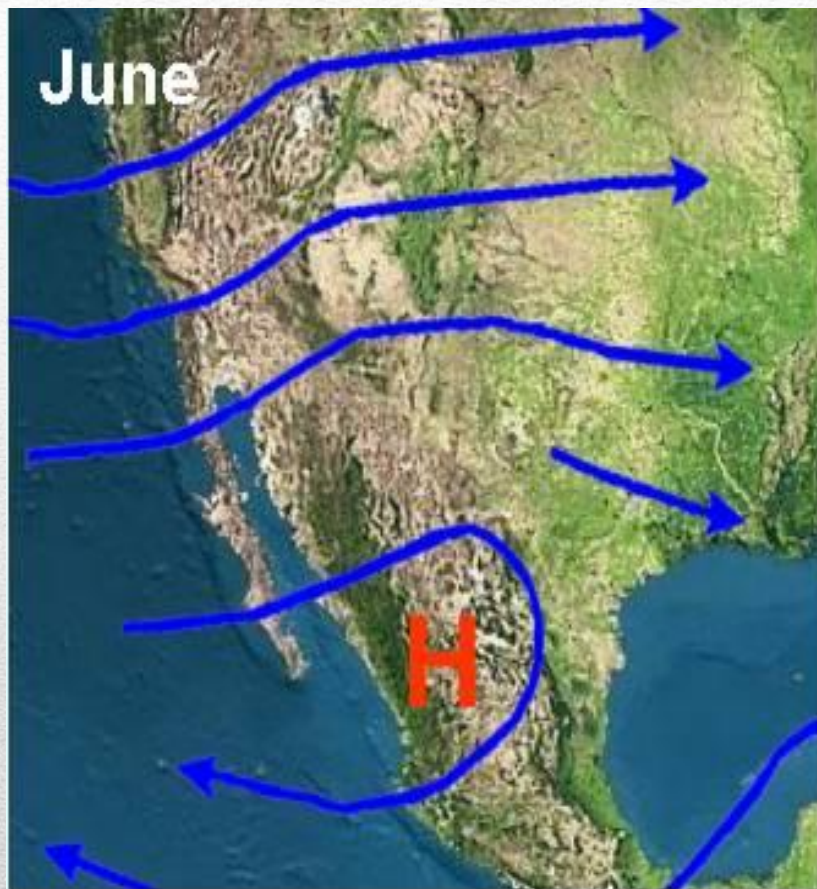
- **Polar Highs**— high pressures cell over Antarctic, strong and persistent. Arctic high is less predominant
 - **Polar Easterlies**— wind system at 60° latitude, moves east to west.
 - **Polar Front**— frontal zone in front of semi permanent lows (Subpolar low pressures) at 50 to 60° latitude, melting ground between the cold winds of the polar easterlies and the warm winds of the Westerlies
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Modifications of the General Circulation

- **Monsoons**
 - **Disturbances in the general pattern of the circulation of the atmosphere**
 - **On-shore flow of winds in the summer, off shore flow in the winter**
 - **Seasonal precipitation; heavy in the summer; dry in the winter.**
 - **Found largely in the South, and Southeastern Asia and Central Africa. (India, Southeastern Asia, and Japan)**
 - **Found in the Southwest United States in summer**
 - **Economic and life preserving in these areas**
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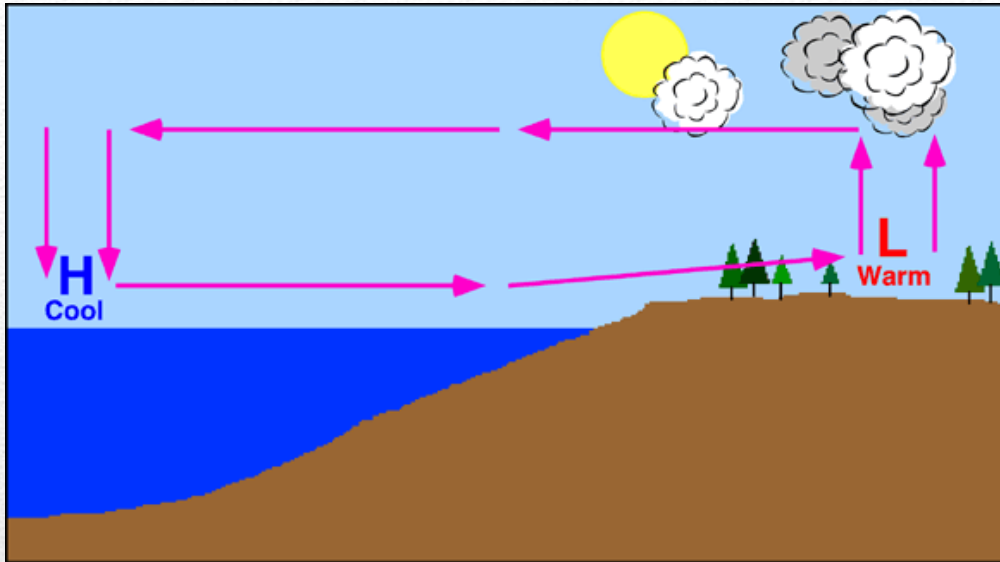




Mean 50 kPa Flow Patterns over SW North America

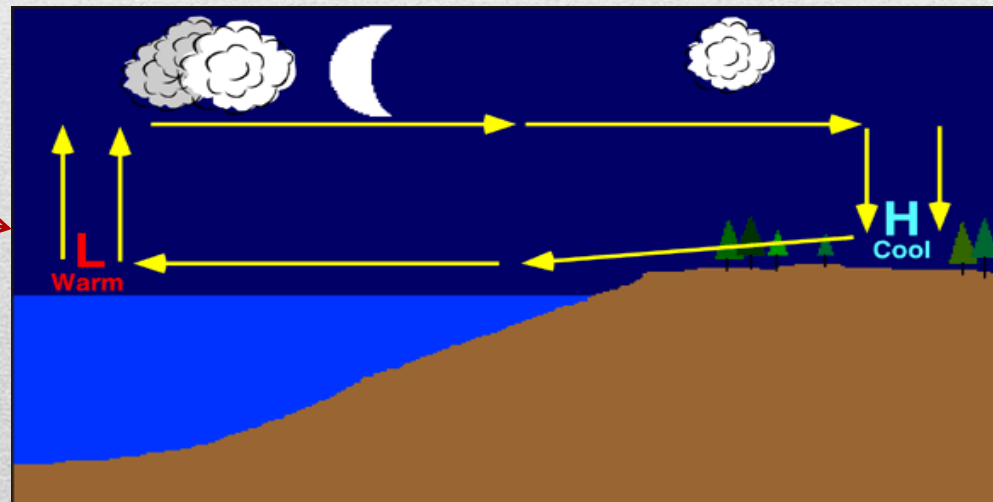
Modification of the General Circulation

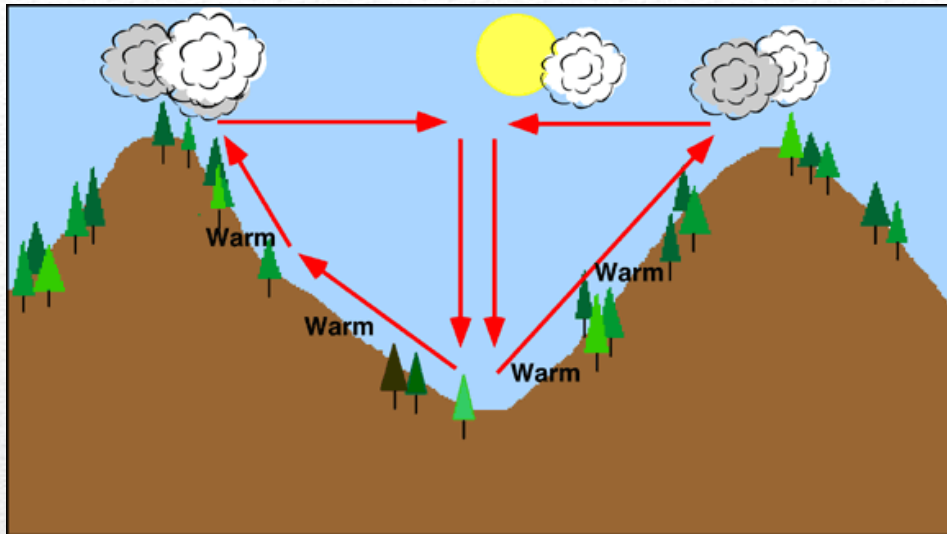
- **Localized Wind Systems**
 - **Sea and Land Breezes**
 - Wind moving from Sea to land and back
 - **Valley and Mountain Breezes**
 - Wind moving from mountains to valleys and back
 - **Katabatic Winds**
 - Originate in cold upland area and cascade towards lower elevations
 - **Foehn/Chinook Winds**
 - Originates only with a steep pressure gradient developing on the windward side of mountains
 - **Santa Ana Winds**
 - Develop from high pressures over Rockies and rush down to California
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← Day
Sea
Breeze

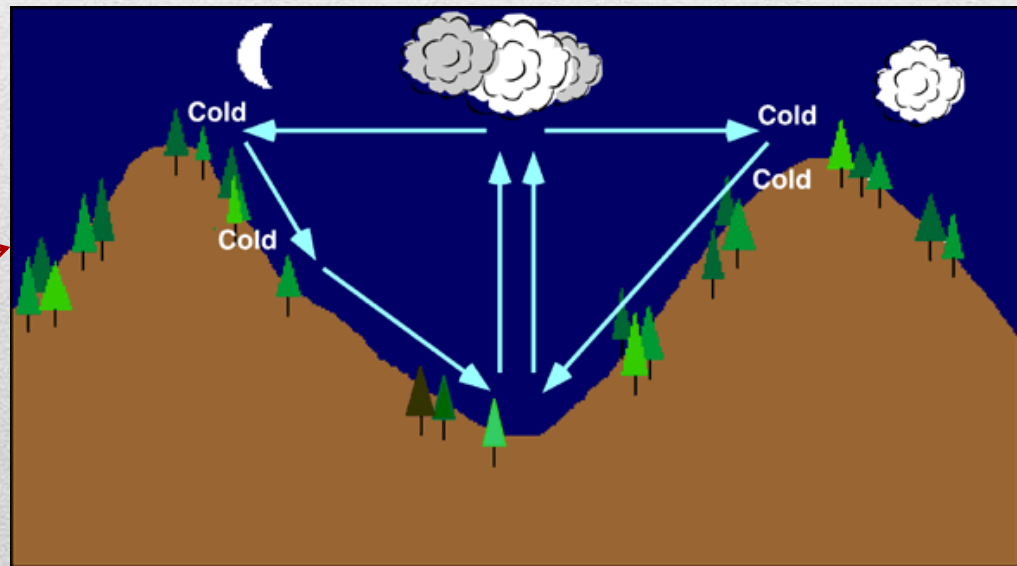
Night
Land
Breeze



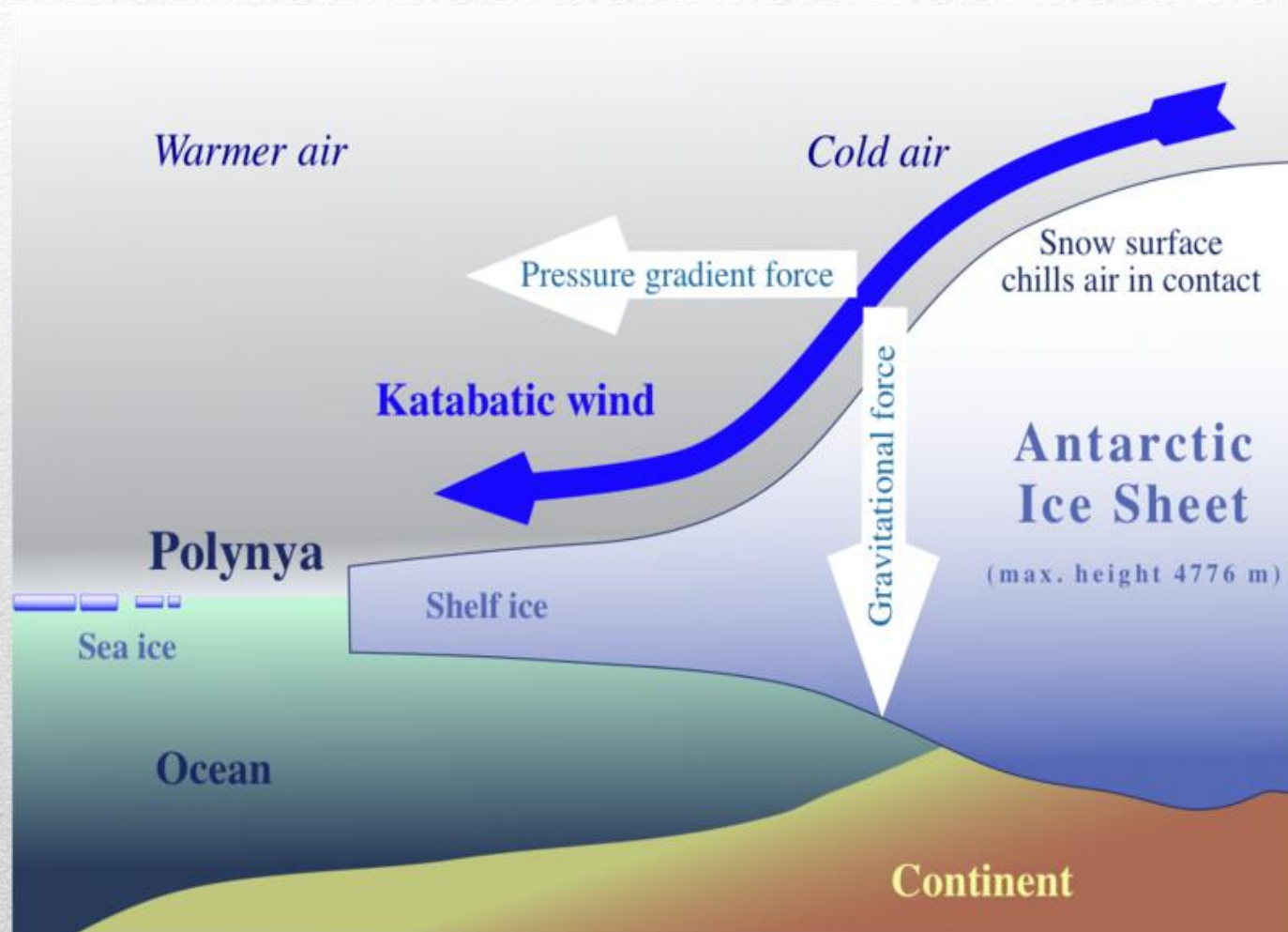


Daytime
Mountain
Breezes

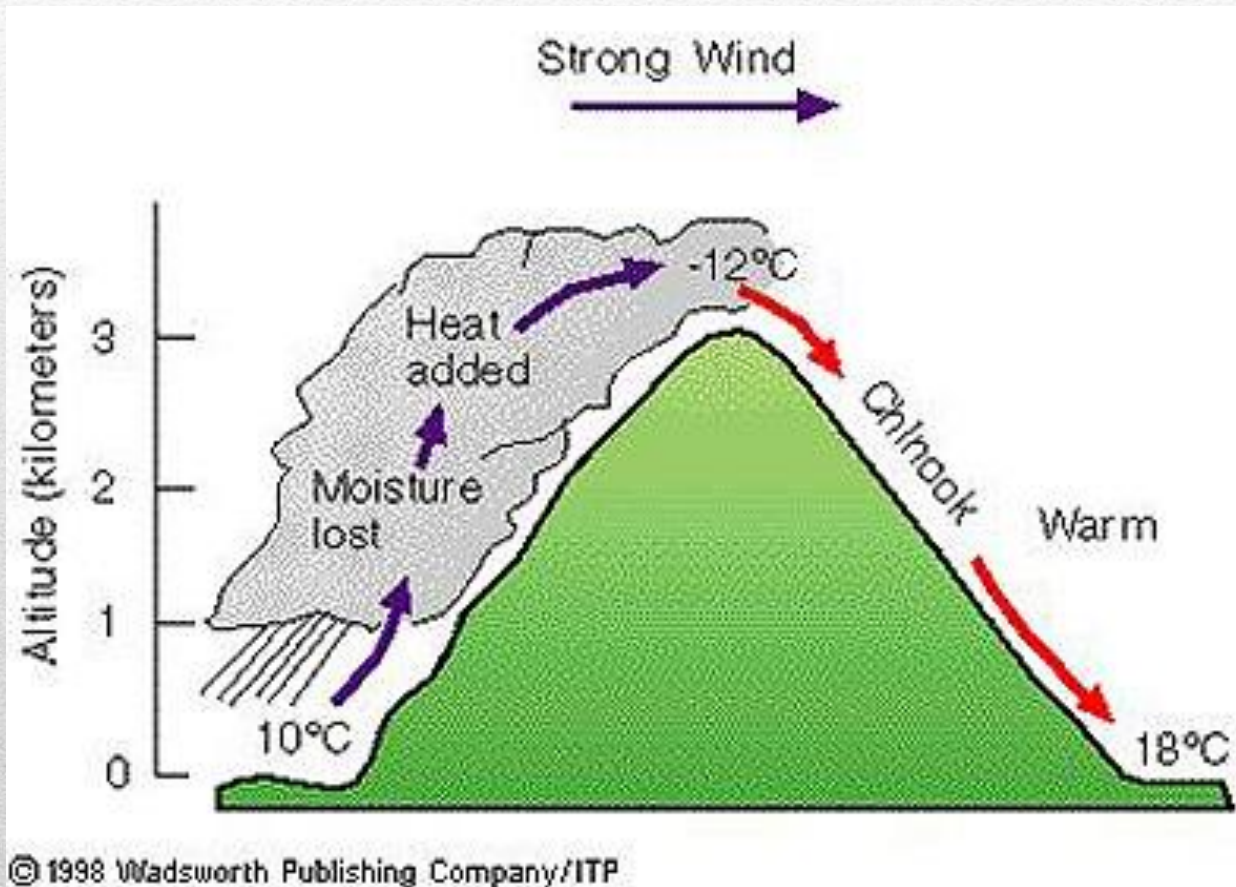
Night
Mountain
Breeze



Katabatic Winds



Chinook Winds



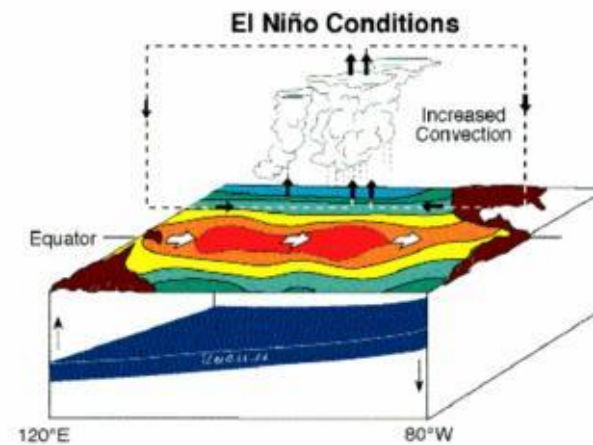
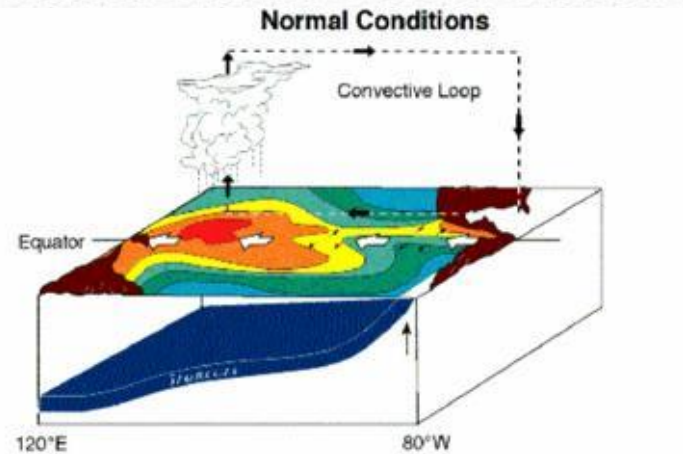
Santa Ana Winds



El Nino- Southern Oscillation

- **An episodic atmospheric and oceanic phenomenon in the Pacific Ocean**
 - **Abnormally warm water appears at the surface of the ocean off the west coast of South America**
 - **Can cause increased rains in northern hemisphere, less fish off the coast of South America, and drought in Southeast Asia**
 - **Causes not totally understood**





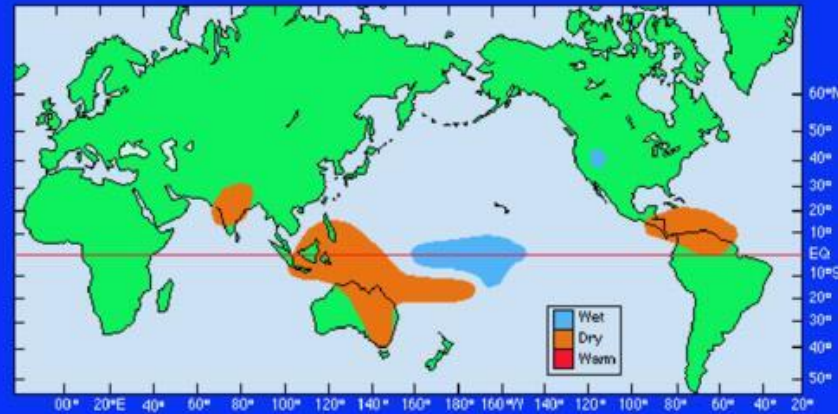
NOAA/PMEL/TAO

Cartoon of the ENSO Ocean/ Atmosphere system (see text for details).
Image from: http://www.pmel.noaa.gov/tao/el_nino/nino-home.html#

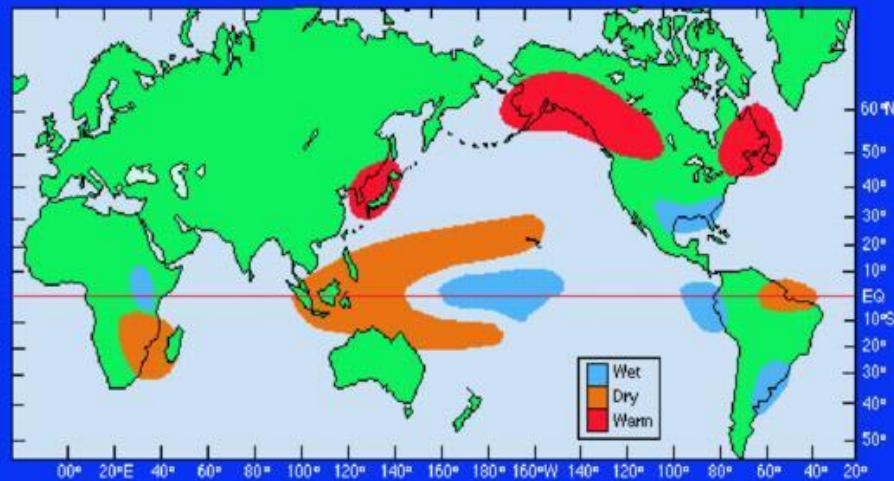
Teleconnections related to El Nino events

<http://www.pmel.noaa.gov/tao/elnino/impacts.html>

Northern Hemisphere Summer



Northern Hemisphere Winter



Other Multi-Year Atmospheric and Oceanic Cycles

- **Pacific Decadal Oscillation**
 - Approximately every 20 to 30 years sea surface temperatures in the northern/west tropical and eastern tropical Pacific Ocean
 - **The North Atlantic Oscillation (NAO) and Arctic Oscillation**
 - The NAO – irregular “seesaw” of pressure differences between two regional components of the general atmospheric circulation of the Northern Atlantic basin
 - Arctic Oscillation alternates warm and cold phases as in the NAO.
-